LITHIUM:
A major **ecological challenge** for **low-carbon mobility**

Key messages from the full report

MINIMAL PROJECT *December 2024*

ASSOCIATION négaWatt

Overcoming barriers to transport decarbonisation

An ever-growing need for lithium

Lithium consumption has risen 4.5-fold in the last eight years, from 38,000 tonnes in 2016 to 180,000 tonnes in 2023. This increase is largely due to its **rapidly growing use in batteries** Fig. 1, which will become dominant in the coming decades.

Decarbonising transport is critical given that the fossil fuels consumed in passenger vehicles represent 11% of global greenhouse gas (GHG) emissions.

Transport must therefore be electrified on a massive scale: electric vehicles already perform better in energy and climate terms than ICE vehicles over their entire lifespan, and this performance will continue to improve with the decarbonisation of energy mixes.

This will increase the demand for lithium to achieve the necessary energy transition in mobility. However, this growing dependence on lithium raises important social and environmental questions.

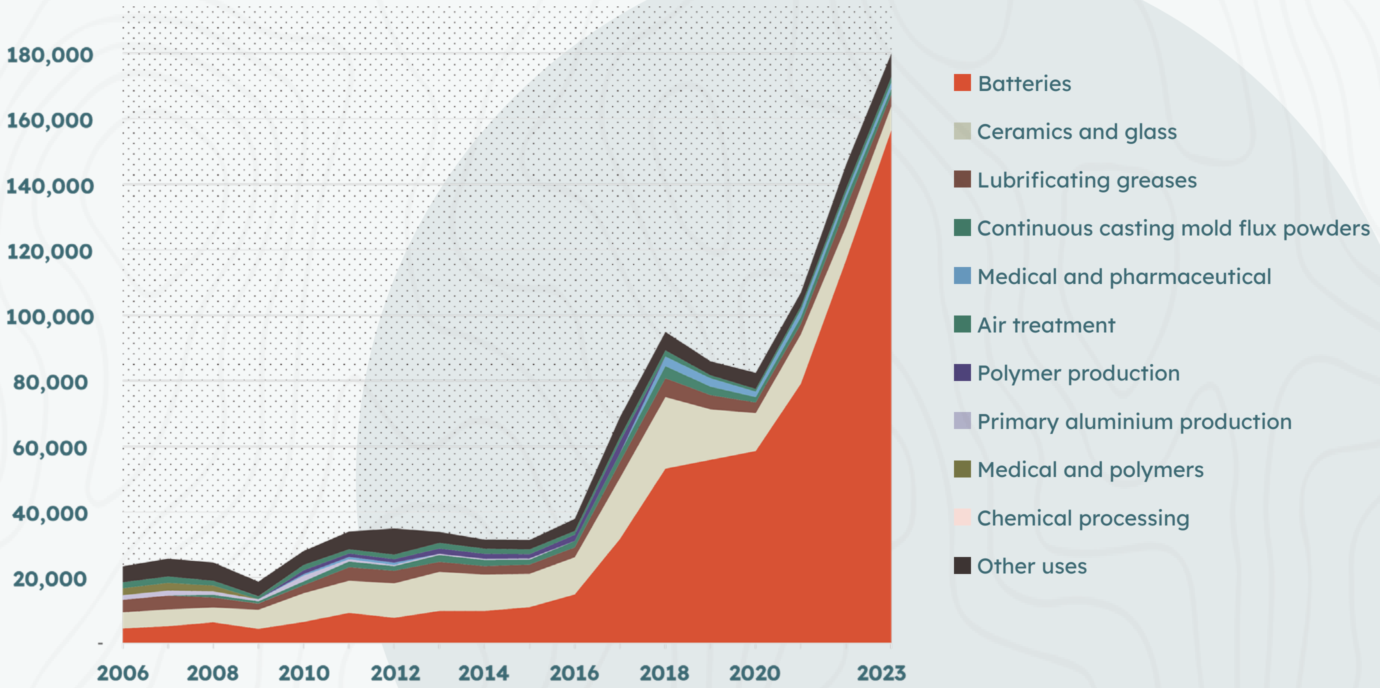

Figure 1

Evolution of global lithium end-uses in tonnes of lithium content per year
(Source: based on USGS data)

A high environmental cost

Humans have already crossed six out of nine planetary boundaries Fig. 2. **Mining and metallurgy in particular have significant environmental impacts**: GHG emissions; destruction of biodiversity; air, water, and soil pollution; eutrophication of aquatic environments; changing land uses; and reduced availability of water resources. Additionally, **the inevitable decline in ore grade** (meaning the expected deterioration in ore quality) **will continue to worsen the impact of mining new metal deposits**. It is important to note that **it remains difficult to decarbonise mining and metallurgical production methods (namely through electrification)**.

For lithium in particular, current production generates a large volume of mining waste per tonne of ore produced, which is higher than other metals. This impact will likely increase considerably in the future, even if the quantities of lithium produced in 2050 will remain much lower than other metals such as iron.

Lithium extraction and production impact water resources to varying degrees depending on the method used. Lithium is currently extracted from two main sources: salt flats (salars) in Latin America, where lithium-rich brine is pumped from deep underground; and hard rock deposits, a more traditional form of mining. Salt flat production **consumes a great deal of water in areas vulnerable to water stress**, with the risk of water table drawdown, low water levels in wells, and decreasing soil humidity. Hard rock extraction can occur in areas not subject to water stress, but this method still consumes a great deal of water, with a potential for future usage conflicts.

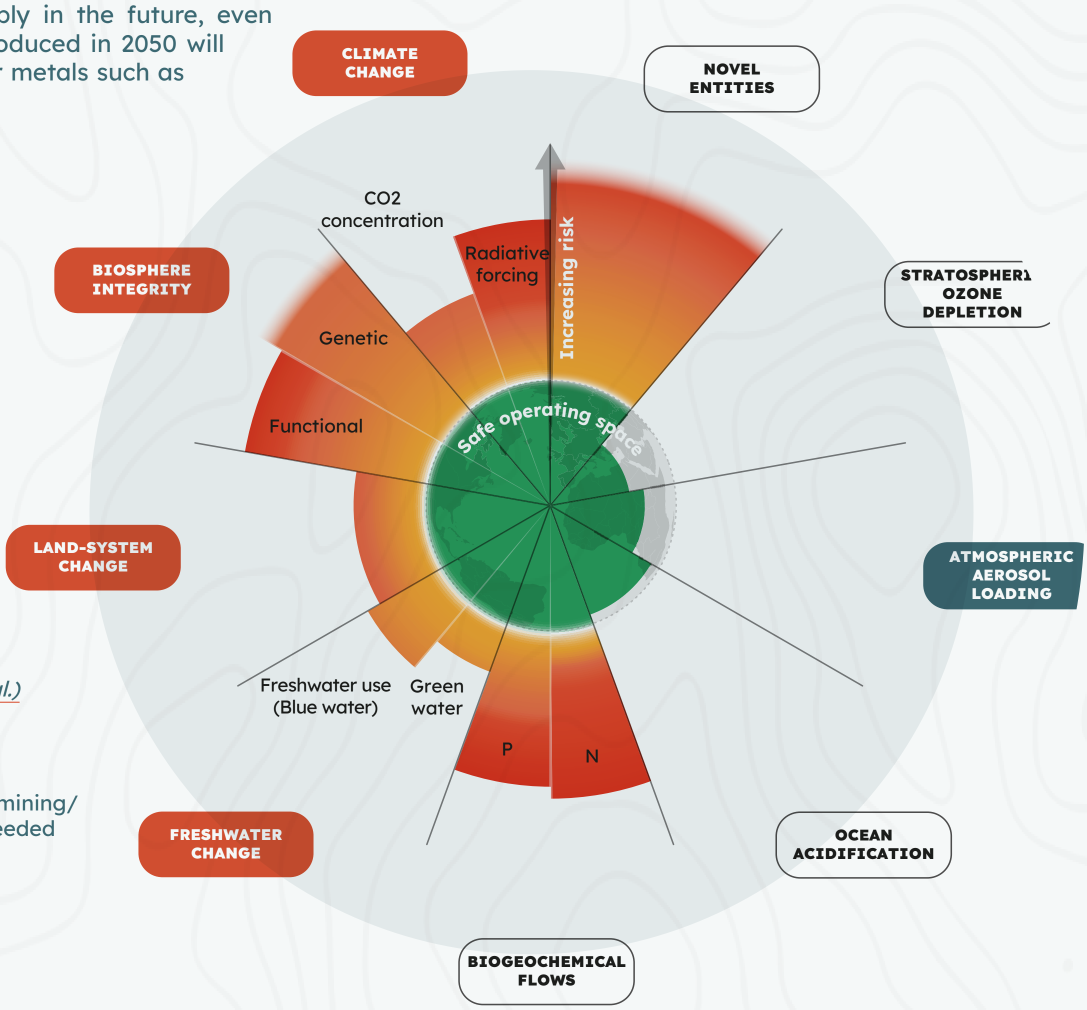

Figure 2

Planetary boundaries and the impacts of metal production
(Source: based on Richardson et al.)

Boundary impacted by mining/metallurgy already exceeded

Boundary impacted by mining and metallurgy

Is recycling a solution?

— **Encouraging and expanding recycling will reduce the environmental footprint** – particularly the carbon footprint – **of primary production**: for lithium, the CO_2 impact of production from recycling is 38% lower than from mining. Recycling is also an efficient and realistic means of relocating some lithium production.

— **However, recycling alone will not eliminate mining in the short term**, since the supply of lithium in end-of-life batteries is still insufficient. This is clear in our reference scenario (see next page), which assumes intensive recycling levels given its necessity.

Establishing a sustainable consumption corridor

In response to this ecological dilemma, we have developed a **sustainable consumption corridor**, a new concept that defines **a safe and just space for the consumption of lithium used in batteries**. This corridor lies between a **foundation, representing the social minimum** that guarantees access to the lithium required for decent living conditions, and a **ceiling, which defines an ecological budget for lithium extraction** above which there is a high risk of violating planetary boundaries.

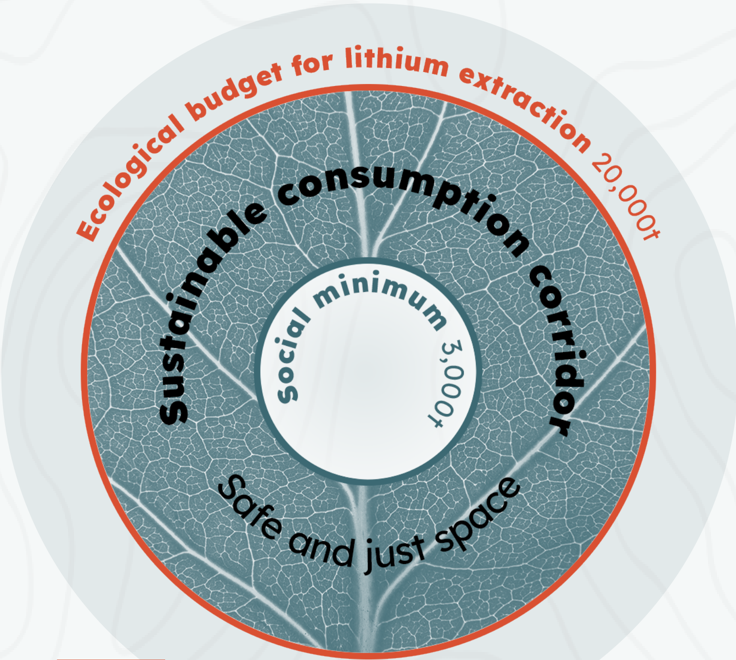

Figure 3
Sustainable lithium consumption corridor in 2050

* The most constraining planetary boundary for the production of all metals combined is climate change. We assume that this will remain the case in 2050. As a first approach, the ecological budget has been calculated only based on this limit.

Human needs that must be met

For the 2018–2050 period, we calculated that 790,000 tonnes of primary lithium are required to meet minimum needs in Europe, or the equivalent of 5.5 years of global production at current levels. For just 2050, the social minimum in Europe is 3,000 tonnes of lithium.

An ecological budget that must be respected

We calculated an ecological budget for lithium extraction in Europe in 2050 of 20,000 tonnes*, which corresponds to a global lithium budget of 459,000 tonnes in 2050. **This ceiling is more than 4 times lower than the projected lithium consumption for 2050 in our reference scenario (see below)**, which is 88,000 tonnes. This shows the urgency of changing our transport modes to make lithium consumption in Europe more sustainable.

Two European scenarios

— **The reference scenario** developed for this analysis, which maintains current mobility levels but assumes total electrification of road transport and very ambitious recycling levels.

— **The CLEVER scenario** focused on sufficiency, developed in collaboration with various European partners. It assumes total electrification of road transport, high electrification levels for freight, and slightly more ambitious recycling levels than the reference scenario.

Cutting lithium consumption in half

Only coordinated action to activate three main drivers — sufficiency, efficiency, and substitution — is likely to keep lithium consumption within planetary boundaries while ensuring a sufficient supply to guarantee decent living conditions for all. A comparison between the CLEVER scenario and the reference scenario Fig.4 shows that **it is possible to cut the EU's lithium consumption in half by 2050**.

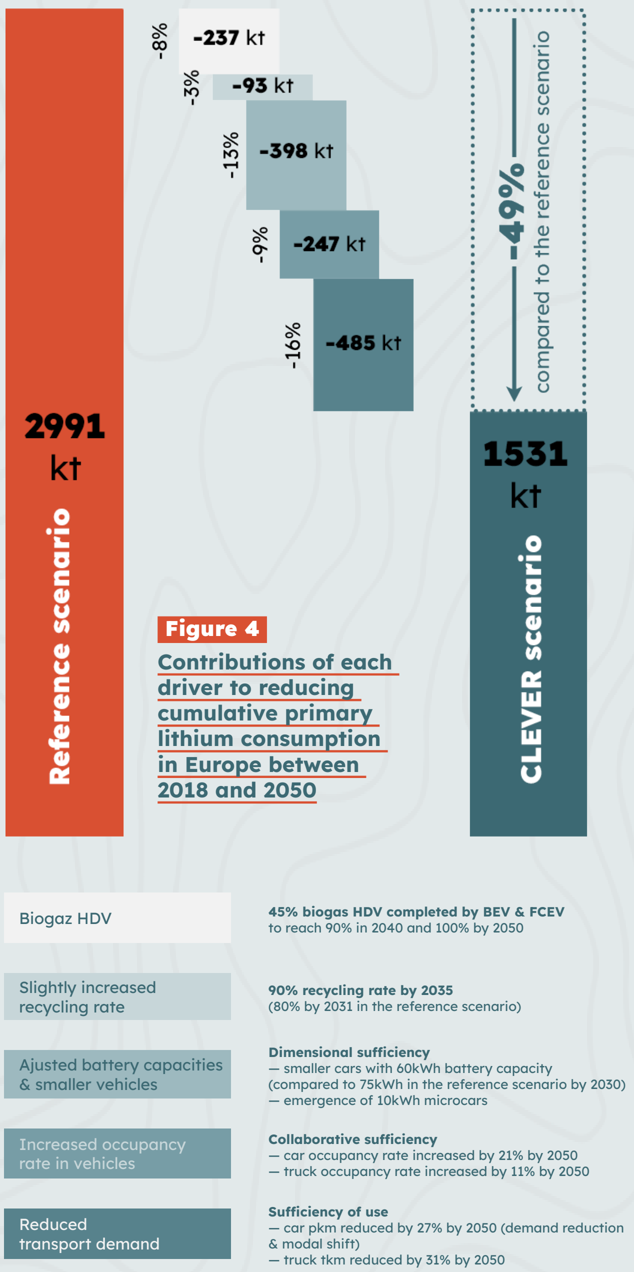

Figure 4
Contributions of each driver to reducing cumulative primary lithium consumption in Europe between 2018 and 2050

1 The importance of sufficiency

The EU faces real threats to its lithium supply, as a gap between demand and the available supply is expected in the coming years. Unfortunately, the EU has only focused on bolstering supply, **even though policies to reduce demand could mitigate these risks more quickly and effectively.** In the reference scenario, the EU's consumption represents nearly 30% of global production in 2050, compared to just 10% in the CLEVER scenario. **Sufficiency offers a significant means of developing a resilient lithium supply and fostering global equity.**

Sufficiency alone is responsible for around 80% of the total reduction in lithium consumption in the CLEVER scenario. It includes the following measures Fig.4 :

— **Limiting vehicle use** (remote work and video conferencing, transferring employees to sites closer to their homes, closer holiday destinations) **and developing alternatives to cars and road freight** (cycling and walking, public transport, rail freight): -16%
— **Reducing the size of cars and batteries**: -13%
— **Expanding carpooling and carsharing**:- 8%

Policy recommendations

— Require manufacturers to respect a target value for average battery capacity to reduce the size and weight of vehicles.

— Prohibit advertising for trips longer than 1,000 km, and/or for any vehicle subject to an ecological penalty.

— Eliminate subsidies for roads and road transport and halt construction of new road infrastructure to funnel those resources into various alternatives.

2 More efficient production processes to reduce local impacts

We must limit the generation of mining waste by prioritising deposits with the highest ore grades and producing as many coproducts as possible.

Though it seems impossible to eliminate the impact of brine extraction on **water resources**, techniques can be used to consume less water during hard rock extraction, such as pressing tailings and recycling water during processing. Nevertheless, a significant amount of water remains trapped in mining tailings and cannot be reused, which increases the quantity of water withdrawn from the natural environment.

As for **GHG emissions**, though there are advantages to shifting some of the production to Europe, the reduction in climate impact remains unclear, given the difficulty in electrifying the chemical treatment of lithium ore concentrate.

Policy recommendations

- **Prohibit mining in protected areas and the most diverse and fragile biomes and prevent the circumvention of EU directives on water, habitat, and birds even in the case of overriding public interest.**
- **Improve the characterisation of mining waste under the EU Extractive Waste Directive** (2006/21/EC) by better evaluating health risks.
- Create a "**European compensation fund for mining waste management**" financed by mining companies.
- **Create and strengthen mechanisms to incite operators to use recycled materials** (set battery collection targets in the automotive industry, recycling targets that exclude lithium recovery for very low-quality end-uses, targets for including recycled materials in batteries to encourage high-quality recycling, etc.).

3 Substitution,or how to replace lithium

Lithium content in vehicles can be reduced through the following measures:

- **Diversifying the propulsion system in trucks:** though short-distance transport (<150 km) must be electrified with batteries, hydrogen and biogas fuels can be used for longer distances. In our analysis, substitution offers an 8% reduction in cumulative primary lithium needs over the 2018–2050 period versus the reference scenario Fig.4.
- **Reducing lithium content for the same battery capacity**, either through changes in the mix of battery types (e.g., evolution in the share of LFP batteries) or technological progress in each battery family. **This would strongly reduce the quantity of lithium needed for the same battery capacity (-32%) between 2020 and 2050.** However, we should note that diversifying battery types will contribute more to resilience than replacing a particular metal with another equivalent technology. Substituting lithium with sodium in batteries could transform the electric vehicle sector by offering a cheaper alternative that seems to have a lower environmental impact. However, technical and environmental challenges in the use of sodium batteries remain.

Outlook and lessons learned

If current trends continue (increased road transport demand; stabilisation of vehicle occupancy rates and freight load factor; the race to extend the range of EVs, and therefore battery size), the ecological ceiling defined in our study will be severely transgressed. Our reference scenario corresponds to 4.4 times our ecological budget for lithium mining in 2050. **One major challenge is the difficulty of accounting for the environmental impacts of metal extraction and processing.**

- **Sufficiency is key to limiting the violation of planetary boundaries and overcoming the real threats to the EU's lithium supply.**
- **Promoting recycling** will also significantly contribute to reducing the environmental footprint of lithium consumption.
- **New mining projects should not be chosen solely based on location or profitability but rather on environmental efficiency criteria** (ore grade, the type of deposit, the vulnerability of local ecosystems, local conflicts around water resources, the presence of potential pollutants, etc.). In this report, we suggest avenues for analysing the environmental quality of various deposits, supplemented by local socio-economic and technical data (in addition to the extensive environmental assessments that must be conducted for each project).

How can we keep the EU's metal consumption within planetary boundaries?

- Association négaWatt co-wrote an **open letter** signed by more than 100 organisations addressed to several European decision-makers and demanding EU legislation on sustainable resource management. This demand was also accompanied by a more complete policy paper, **Sustainable Resource Management in the EU**, published in February 2024.
- Through this initiative, we call for binding targets for resource consumption and highlight the need for sector-specific targets. This study presents an initial proposal for a sustainable consumption corridor to set a binding target for lithium consumption. We also identify several drivers and policies that could ensure the EU remains within a safe and just space for the lithium used in batteries.

The Minimal Project

Climate change presents a complex challenge, as it is inextricably linked to other environmental issues. A paradox emerges: while reducing greenhouse gas emissions is crucial, increased demand for the mineral resources required for decarbonisation may exacerbate environmental impacts.

This raises several questions: How can we determine our true need for metals to ensure quality of life while enacting the energy transition? What criteria should guide the prioritisation of these needs to minimise extraction? Furthermore, how can we ensure equitable global access to mineral resources?

The Minimal project, developed by the French not-for-profit organisation Association négaWatt, examines potential shifts in the production and consumption of critical metals needed for the energy transition. This project begins with an analysis of lithium, the first metal to be studied.

Full report available on:
www.negawatt.org/MINIMAL-lithium

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